Journal of Scientific Temper
Vol 14 (2), April-June 2026, pp. 134-149
DOI: 10.56042/jst.v14i2.31406

OPINION

Scientific Temper: The Invisible Foundation of Disaster Preparedness and Disaster Management

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ABSTRACT

Hazards are an inevitable part of nature, technology, and modern society. They may arise from natural processes such as floods, cyclones, landslides, heat waves, and cold waves, or from human activities and technological systems such as fires, industrial accidents, chemical leaks, road crashes, and hospital emergencies. However, hazards do not automatically become disasters. Disasters occur when hazards interact with exposure, vulnerability, unsafe behavior, weak preparedness, and inadequate coping capacity. Recent incidents involving residential fires caused by overloaded electrical systems, boat capsizing despite weather warnings, ICU fires, industrial accidents, urban flooding, landslides, road crashes, heat waves, and cold waves demonstrate that disasters are often amplified by the absence of scientific temper in everyday life. This article explains the scientific distinction between hazards and disasters and argues that scientific temper is the invisible foundation of resilience. It transforms warnings into action, safety norms into culture, and preparedness into collective responsibility. Building a disaster-resilient India therefore requires not only advanced technologies and institutional mechanisms, but also scientifically informed citizens capable of understanding risks, respecting evidence, and acting responsibly.

Keywords: Scientific temper; hazard; disaster; disaster risk reduction; preparedness; resilience; safety culture; vulnerability; risk perception; public safety.

1. Introduction: Hazards Do Not Automatically Become Disasters

India today faces a wide spectrum of hazards that threaten life, infrastructure, environment, and economic stability. Some hazards originate from natural processes, while others emerge from technological systems and human activities.

Hazards may broadly be classified into:

1. Natural hazards, including floods, cyclones, landslides, earthquakes, heat waves, and cold waves;
2. Human-made or technological hazards, including fires, industrial accidents, chemical leaks, electrical failures, transport accidents, and hospital fires.

According to the United Nations Office for Disaster Risk Reduction, a hazard is a process, phenomenon, or human activity that may cause loss of life, injury, or damage, whereas a disaster is a serious disruption occurring when hazards interact with exposure, vulnerability, and insufficient coping capacity (United Nations Office for Disaster Risk Reduction, 2015 & 2017).

Thus:

(i) Heavy rainfall is a hazard; urban flooding caused by blocked drainage becomes a disaster.

(ii) A cyclone is a hazard; ignoring evacuation warnings converts it into disaster.

(iii) An electrical short circuit is a hazard; a residential fire trapping families becomes a disaster.

(iv) Oxygen-rich ICU environments are technological hazards; ICU fires become disasters when safety systems fail.

Disaster risk therefore emerges from the interaction among:

(i) Hazard,

(ii) Exposure,

(iii) Vulnerability,

(iv) Preparedness,

(v) Coping capacity.

The difference between hazard and disaster is often determined by preparedness, societal behavior, institutional responsibility, and scientific understanding (*The Constitution of India, 2024*).

The Constitution of India recognizes the development of scientific temper, humanism, and the spirit of inquiry and reform as a fundamental duty under Article 51A(h) (Aswal, 2026). Scientific temper is not limited to scientific laboratories or academic institutions. It is a societal way of thinking based on evidence, rationality, observation, discipline, and understanding cause-and-effect relationships.

In disaster risk reduction (DRR), scientific temper means:

(i) Respecting scientific evidence,

(ii) Understanding hazards,

(iii) Trusting early warnings,

(iv) Following safety protocols,

(v) Avoiding panic,

(vi) Learning from failures,

(vii) Promoting accountability.

Preparedness therefore is not merely a governmental responsibility. It is a societal culture rooted in scientific thinking**.**

Figure 1. Conceptual framework showing how scientific temper transforms hazards into manageable risks through preparedness, safety culture, scientific awareness, and resilience-building.

2. Scientific Temper and the Science of Disaster Risk Reduction

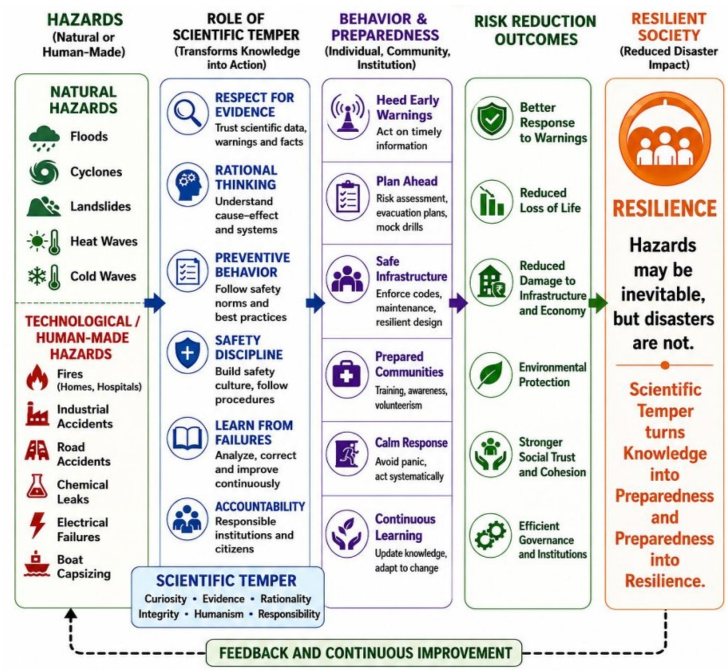
Modern disaster management has evolved from reactive relief-oriented approaches toward proactive risk reduction and resilience-building (Aswal , 2026; Wisner *et al.* 2004). The Sendai Framework for Disaster Risk Reduction emphasizes:

(i) Understanding disaster risk,

(ii) Strengthening governance,

(iii) Investing in resilience,

(iv) Enhancing preparedness for effective response and recovery (United Nations Office for Disaster Risk Reduction, 2015).



Scientific temper strengthens all these dimensions because disasters are rarely caused by hazards alone. As explained by Wisner and colleagues in *At Risk*, disasters emerge when hazards interact with social vulnerability and unsafe conditions (Reason, 1990).

Similarly, Reason’s theory of human error demonstrates that accidents often arise not from a single mistake but from multiple latent system failures aligning simultaneously (Perrow, 1984). Perrow’s theory of “normal accidents” further explains that failures in tightly coupled technological systems can cascade rapidly when safety culture and preparedness are weak (National Disaster Management Authority, 2019). Hollnagel’s resilience engineering perspective emphasizes that safety depends not merely on avoiding failure, but on continuously adapting systems to changing conditions (Hollnagel, 2014).

Scientific temper therefore acts as a bridge between knowledge and resilience, as schematically depicted in Figure 1.

3. Residential Fires: When Everyday Hazards Become Disasters

Increasing urban temperatures and changing lifestyles have led to widespread use of air conditioners across Indian cities. Although air conditioners improve thermal comfort, they significantly increase electrical load.

The hazard emerges when:

(i) Old wiring is overloaded,

(ii) Poor-quality cables are used,

(iii) Electrical audits are absent,

(iv) Maintenance is neglected,

(v) Multiple appliances overload circuits.

A short circuit initially remains a localized electrical hazard. However, recent residential fire incidents demonstrate how rapidly such hazards can escalate into disasters.

Scientifically, fire growth depends upon the interaction among:

(i) Fuel,

(ii) Heat,

(iii) Oxygen,

(iv) Chain reactions.

Enclosed balconies and blocked ventilation pathways worsen fire dynamics by increasing smoke accumulation and reducing heat dissipation. During fires:

(i) Toxic smoke spreads rapidly,

(ii) Temperatures rise sharply,

(iii) Escape pathways become blocked,

(iv) Firefighting access becomes difficult.

The tragedy therefore is not merely electrical failure—it is failure of scientific awareness and safety culture.

Preparedness begins before fire occurs.

4. Boat Capsizing: Warnings Save Lives Only When Society Responds Scientifically

Modern meteorological science can predict rough seas, storms, heavy rainfall, and high winds with remarkable accuracy. India's disaster management framework strongly emphasizes early warning dissemination and preparedness (Constitution of India, 2024).

Thus, bad weather itself is a hazard—not automatically a disaster.

Disaster occurs when warnings are ignored.

Several boat tragedies have revealed recurring failures:

(i) Overloading of boats,

(ii) Absence of life jackets,

(iii) Ignoring weather advisories,

(iv) Lack of emergency preparedness,

(v) Panic during instability.

Scientifically, vessel stability depends upon balance between buoyancy, center of gravity, and metacentric stability. Sudden passenger movement alters mass distribution and destabilizes the vessel.

Thus, panic itself can amplify disaster.

Preparedness therefore is not merely availability of equipment. It is behavioral readiness rooted in scientific understanding.

5. ICU Fires: Technology Without Safety Culture

Hospitals symbolize healing and protection, yet repeated ICU fires demonstrate how technologically advanced systems can become disaster zones when safety culture weakens.

ICUs contain several interacting hazards:

(i) Oxygen-rich atmosphere,

(ii) Continuous electrical load,

(iii) Plastic-intensive equipment,

(iv) Critically immobile patients,

(v) High fire load density.

Scientifically, oxygen does not burn itself, but oxygen enrichment significantly accelerates combustion and reduces ignition thresholds. Even minor electrical sparks may produce rapid fire spread.

Investigations into ICU fires commonly identify:

(i) Electrical overload,

(ii) Unsafe wiring,

(iii) Poor maintenance,

(iv) Non-functional alarms,

(v) Inadequate evacuation planning,

(vi) Absence of mock drills.

These failures represent classic examples of cascading system failures.

Technology alone cannot guarantee safety.

Scientific temper in healthcare requires:

(i) Hazard identification,

(ii) Preventive maintenance,

(iii) Safety audits,

(iv) Fire drills,

(v) Systems thinking,

(vi) Institutional accountability.

Safety must become scientific culture—not merely compliance paperwork.

6. Road Accidents: Everyday Violations of Scientific Principles

Road accidents represent one of the largest silent disasters globally. The World Health Organization identifies road traffic injuries as a major public health challenge (WHO, 2024; NCRB 2023).

The hazards involved are scientifically straightforward:

(i) Speed,

(ii) Momentum,

(iii) Reaction time,
(iv) Fatigue,
(v) Impact forces,
(vi) Reduced visibility.

The severity of road accidents increases sharply with speed because kinetic energy rises with the square of velocity.

Similarly, higher momentum makes stopping more difficult and collisions more destructive.

Yet many individuals continue to ignore:

(i) Helmets,
(ii) Seat belts,
(iii) Speed limits,
(iv) Lane discipline.

Scientific temper transforms this simple physics into responsible behavior.

A helmet is not merely a legal requirement; it is applied impact science.

A seat belt is not inconvenience; it is protection against uncontrolled deceleration forces.

7. Floods, Cyclones, and Landslides: Natural Hazards Amplified by Human Vulnerability

India's geography naturally exposes it to floods, cyclones, cloudbursts, and landslides. These are natural hazards associated with climate systems, rivers, oceans, and mountain environments.

However, disasters become severe primarily when scientific planning and preparedness are absent.

7.1 Floods: Water Always Returns to Its Path

Rainfall itself is natural. Urban flooding often emerges from ignoring scientific principles of drainage and land-use planning. National Disaster Management Authority guidelines emphasize floodplain management and scientific drainage systems (*National Guidelines on Management of Urban Flooding, 2010*).

Flood disasters intensify when:

(i) Wetlands are destroyed,

(ii) Rivers are narrowed,

(iii) Storm-water drains are blocked,

(iv) Construction occurs in floodplains.

Scientifically, water always seeks its natural flow pathway.

Thus, many floods are not only meteorological events but also planning failures.

7.2 Cyclones: Forecasting Alone Cannot Save Lives

India has made major advances in cyclone forecasting and early warning systems (*Cyclone Warning and Preparedness Systems in India 2007)*.

Yet cyclones still become disasters when:

(i) Warnings are ignored,

(ii) Coastal regulations are violated,

(iii) Weak structures remain vulnerable,

(iv) Fishing communities enter sea despite warnings.

Preparedness before disaster always saves more lives than rescue afterward.

7.3 Landslides: Ignoring Mountain Science

Mountain ecosystems such as the Himalayas are naturally fragile. Landslides are associated with rainfall, geology, slope instability, earthquakes, and drainage disruption.

Disasters intensify when developmental activities ignore geological science.

Major contributing factors include:

(i) Unscientific hill cutting,

(ii) Deforestation,

(iii) Improper drainage,

(iv) Construction on unstable slopes,

(v) Excessive excavation.

Scientific temper in mountain development requires:

(i) Geological assessment,

(ii) Controlled construction,

(iii) Drainage planning,

(iv) Afforestation,

(v) Monitoring unstable zones.

Nature often provides warning signs before disaster. Scientific awareness helps society recognize them.

8. Chemical and Industrial Accidents: When Small Failures Cascade

Industrial development improves quality of life but also introduces technological hazards involving:

(i) Toxic chemicals,

(ii) Pressure systems,

(iii) Flammable materials,

(iv) Explosive atmospheres.

Industrial accidents commonly involve:

(i) Poor maintenance,

(ii) Ignored warning signs,

(iii) Human error,

(iv) Inadequate training,

(v) Failure of safety systems.

Scientifically, accidents rarely result from a single cause. They usually emerge through cascading failures in tightly coupled systems (*Cyclone Warning and Preparedness Systems in India 2007)*..

Examples include:

(i) Gas leakage followed by ignition,

(ii) Pressure buildup causing explosion,

(iii) Toxic release from incompatible chemical storage,

(iv) Electrical sparks igniting flammable vapors.

Scientific temper in industrial systems requires:

(i) Process safety management,

(ii) Safety audits,

(iii) Mock drills,

(iv) Transparent reporting,

(v) Continuous training,

(vi) Community awareness.

Preparedness must become part of industrial culture.

9. Heat Waves and Cold Waves: Silent but Deadly Hazards

Not all disasters arrive dramatically. Some evolve gradually and silently.

Climate change is increasing the frequency and intensity of extreme weather events globally (*Climate Change 2023: Synthesis Report*. IPCC, 2023).

9.1 Heat Waves

Heat waves are increasingly affecting India due to climate variability and urban heat-island effects (*National Guidelines for Preparation of Action Plan – Prevention and Management of Heat Wave, 2019; WHO 2021*).

Extreme heat becomes disastrous when:

(i) Hydration is neglected,

(ii) Outdoor exposure continues,

(iii) Heat advisories are ignored,

(iv) Vulnerable populations remain unsupported.

Scientifically, heat-related illness progresses from dehydration and exhaustion to heat stroke and organ failure.

Scientific temper promotes:

(i) Hydration,

(ii) Ventilation,

(iii) Heat preparedness,

(iv) Urban greening,

(v) Community awareness.

9.2 Cold Waves

Cold waves particularly affect poor and vulnerable populations lacking adequate shelter.

Scientifically, prolonged cold exposure may lead to:

(i) Hypothermia,

(ii) Respiratory complications,

(iii) Cardiovascular stress.

Preparedness includes:

- Community shelters,
- Public advisories,
- Safe heating awareness,
- Protection of vulnerable populations.

Scientific temper helps society understand that seasonal extremes are serious physiological risks—not merely discomfort.

10. Scientific Temper Across the Disaster Risk Reduction Cycle

Scientific temper influences every phase of disaster risk reduction—from hazard identification to recovery and resilience-building. Table 1 summarises the disaster outcomes when scientific temper is ignored. Table 2 summarises role of scientific temper across the DRR cycle.

Table 1. Scientific Principle Ignored vs Disaster Outcome

Hazard / Situation	**Scientific Principle Ignored**	**Resulting Disaster Outcome**	**Scientific Temper–Based Preventive Approach**
Residential electrical fire	Electrical load limits and fire dynamics	Short circuit and fatal fires	Electrical audits and preventive maintenance
Boat capsizing	Stability and buoyancy principles	Capsizing and drowning	Passenger discipline and early warning compliance

ICU fires	Oxygen-enriched combustion	Rapid fire spread in hospitals	Fire safety culture and mock drills
Urban flooding	Natural drainage pathways	Severe urban flooding	Scientific urban planning
Landslides	Slope stability and drainage science	Slope collapse and destruction	Geological assessment and controlled construction
Industrial accidents	Cascading system failures	Explosions and toxic release	Process safety management
Heat waves	Human thermoregula tion limits	Heat stroke and mortality	Hydration and heat action plans
Road accidents	Kinetic energy and momentum	Severe collisions and fatalities	Speed discipline and protective systems

Table 2. Role of Scientific Temper Across the DRR Cycle

DRR Phase	Role of Scientific Temper	Expected Outcome
Risk assessment	Evidence-based understanding of hazards	Early identification of vulnerabilities
Prevention	Respect for scientific regulations	Reduced unsafe development
Mitigation	Long-term resilience planning	Lower disaster losses
Preparedness	Conversion of knowledge into action	Faster emergency response
Early warning	Trust in scientific advisories	Reduced casualties
Emergency response	Calm and disciplined behavior	Reduced panic and secondary damage

Recovery	Learning from failures	Faster restoration
Reconstruction	Build Back Better approach	Improved future resilience
Capacity building	Continuous education and training	Strong preparedness culture
Governance	Accountability and evidence-based policy	Stronger institutions

11. Building a Scientifically Prepared India

India's future resilience depends upon transforming preparedness into societal culture.

The Disaster Management Act, 2005 and the National Disaster Management Plan emphasize preparedness, mitigation, awareness, and institutional coordination (*National Disaster Management Plan 2019; Disaster Management Act, 2005*).

However, long-term resilience also requires scientifically informed citizens.

This requires:

(i) Disaster education,

(ii) Public awareness,

(iii) Institutional accountability,

(iv) Mock drills,

(v) Safety audits,

(vi) Responsible media communication,

(vii) Community participation,

(viii) Evidence-based governance.

Preparedness must become continuous societal behavior rather than temporary compliance.

12. Conclusion: Scientific Temper Converts Vulnerability into Resilience

Natural and technological hazards will always exist in society. Fires, floods, cyclones, industrial accidents, road crashes, heat waves, landslides, and technological failures cannot be completely eliminated.

But disasters are often preventable.

The true difference between hazard and disaster lies in preparedness, scientific awareness, responsible behavior, and societal discipline.

From residential fires and ICU tragedies to floods, cyclones, industrial accidents, road crashes, and heat waves, one lesson remains constant:

Hazards become disasters when science is ignored, warnings are neglected, and preparedness is absent.

Scientific temper enables individuals and institutions to:

(i) Recognize risks early,

(ii) Respect evidence,

(iii) Follow safety practices,

(iv) Avoid panic,

(v) Learn from failures,

(vi) Build resilience.

India's journey toward disaster resilience therefore requires not only advanced technologies and stronger institutions, but also scientifically aware citizens who transform preparedness into a way of life.

Scientific temper is not merely essential for scientific progress.

It is essential for protecting human life itself.

Acknowledgement

The author wishes to place on record sincere gratitude to Dr. Krishna S. Vatsa and Ms. Rita Missal for their collegial support.

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